Design and Kinematic Analysis of Stair Climbing Rocker Bogie Mechanism

Mr. Kapre K. B[1] Mr. Shaikh A. A[2] Mr. Sathe A. D.[3] Mr. Suradkar R. P.[4] Prof. Shinde R. S.[5]
[1,2,3,4]B.E. Student [5]Assistant Professor
[1,2,3,4,5]Department of Mechanical Engineering
[1,2,3,4,5]PREC, Loni, SPPU, Pune, India

Abstract— A rocker bogie mechanism is a vehicle for driving over rough terrain, especially one driven by remote control over extraterrestrial terrain. Robotic rovers are used extensively for exploratory and reconnaissance purposes in the fields of scientific exploration and defense. This project focuses on the design and development of a rover with autonomous driving and environmental sensing capability. It can be used as an exploratory rover, providing information about the terrain and surrounding atmosphere. It can also be used as a surveillance robot to alert people in areas with security threats like national borders, terrorist occupied territories etc., where it is difficult for humans to work. The rover will be having a Rocker Bogie Suspension system with 6 wheels for greater stability in maneuvering over obstacles. It can avoid un-mountable obstacles and can traverse over mountable obstacles. Instructions are sent to the rover by a remote computer connected over Wi-Fi. The rover is equipped to send a live video feed and sensor data to the remote computer.

Keywords: Rocker, Bogie, Stair Climbing, Obstacle Riding, ECU

I. INTRODUCTION

The place, where the value of gravity remains lower than earth's own gravitational coefficient, at that place the existing suspension system fails to fulfill desired results as the amount and mode of shock absorbing changes. To counter anti-gravity impact, NASA and Jet Propulsion Laboratory have jointly developed a suspension system called the rocker-bogie Suspension system. It is basically a suspension arrangement used in mechanical robotic vehicles used specifically for space exploration. The rocker-bogie suspension based rovers has been successfully introduced for the Mars Pathfinder and Mars Exploration Rover (MER) and Mars Science Laboratory (MSL) missions conducted by apex space exploration agencies throughout the world. The proposed suspension system is currently the most favored design for every space exploration company indulges in the business of space research. The motive of this research initiation is to understand mechanical design and its advantages of Rocker- bogie suspension system in order to find suitability to implement it in conventional loading vehicles to enhance their efficiency and also to cut down the maintenance related expenses of conventional suspension systems.

The rocker-bogie design has no springs or stub axles for each wheel, allowing the rover to climb over obstacles, such as rocks, that are up to twice the wheel's diameter in size while keeping all six wheels on the ground. As with any suspension system, the tilt stability is limited by the height of the center of gravity. Systems using springs tend to tip more easily as the loaded side yields. Based on the center of mass, the Curiosity rover of the Mars Science Laboratory mission can withstand a tilt of at least 45 degrees in any direction without overturning, but automatic sensors limit the rover from exceeding 30-degree tilts. The system is designed to be used at slow speed of around 10 centimeters per second (3.9 in/s) so as to minimize dynamic shocks and consequential damage to the vehicle when surmounting sizable obstacles.

Over the past decade, the rocker-bogie suspension design has become a proven mobility application known for its superior vehicle stability and obstacle-climbing capability. Following several technology and research rover implementations, the system was successfully flown as part of Mars Pathfinder's Sojourner rover. When the Mars Exploration Rover (MER) Project was first proposed, the use of a rocker-bogie suspension was the obvious choice due to its extensive heritage. The challenge posed by MER was to design a lightweight rocker-bogie suspension that would permit the mobility to stow within the limited space available and deploy into a configuration that the rover could then safely use to egress from the Lander and explore the Martian surface. When building a robot you'd like it to be as simple as possible. In most cases you'd never need a suspension system, but there were several instances when a suspension system cannot be avoided. The term "bogie "refers to the links that have a drive wheel at each end. Bogies were commonly used as load wheels in the tracks of army tanks as idlers distributing the load over the terrain. Bogies were also quite commonly used on the trailers of semi-trailer trucks. Both applications now prefer trailing arm suspensions. The rocker-bogie design has no springs or stub axles for each wheel, allowing the rover to climb over obstacles, such as rocks, that are up to twice the wheel's diameter in size while keeping all six wheels on the ground. As with any suspension system, the tilt stability is limited by the height of the centre of gravity.

The initiation of rocker bogie suspension system can be traced to the development of planetary rover which is mobile robots, especially designed to move on a planet surface. Early rovers were tele-operated like the Lunokhod I while recent ones are fully autonomous, such as fido, Discovery and recently developed Curiosity mars exploration rover. The rovers needed to be very robust and reliable, as it has to withstand dust, strong winds, corrosion and large temperature changes under mysterious conditions. Maximum rovers remain powered by batteries which are recharged by solar panels during the day installed over there surface. The locomotion system of rovers remains crucial to enable it to reach objective sites, conduct research, and collect data and to position itself according to the demand. There are three main types of rover locomotion developed so far i.e. wheeled, legged and caterpillar locomotion. The main difference between the miscellaneous designs of planetary robots lies in the type of locomotion system. Even after developing many legged and hybrid robots, most researchers still focus on

wheeled locomotion for rovers because of its locomotive ease and advantages and among wheeled locomotion design, the rocker bogie suspension system based design remain most favored. The ancient fido rover and the Sojourner contain 6 independently steered and driven wheels suspended from a rocker-bogie mechanism for maximum suspension and ground clearance. Rocky Seven Rover has a similar suspension system just differ in front wheels. The Nanorover & Nomad Rovers have four steered wheels suspended from two bogies & CRAB Rover utilizes two parallel bogie mechanisms on each side to overcome obstacles and large holes. As far as the initial research is concerned, the software optimization seeks for an optimum in the constrained solution space given an initial solution and Dr. Li et al. derive a mathematical model to generalize rover suspension parameters which define the geometry of the rocker-bogie system. The objective behind evolution of rocker bogie suspension system is to develop a system which minimizes the energy consumption, the vertical displacement of the rover's centre of mass and its pitch angle. In this research, our endeavor is to transfer these major advantages embedded with the rocker bogie system into conventional vehicles in order to remove discomfort and complexities present in conventional suspension system in general and suspension system of heavy vehicles in particular

A. Objectives:

1) We have to climb the obstacles or ride on the abnormal surface and
2) It can climb max slope of 45degree with the help of such a rocker bogie mechanism.

This mechanism serves our objective because of its nature of allowing flexibility in linkages when wheel climb or goes from the abnormal road surface.

II. CONSTRUCTION AND WORKING

A. Rocker

The term "rocker" describes the rocking aspect of the larger links present each side of the suspension system and balance the bogie as these rockers are connected to each other and the vehicle chassis through a selectively modified differential.

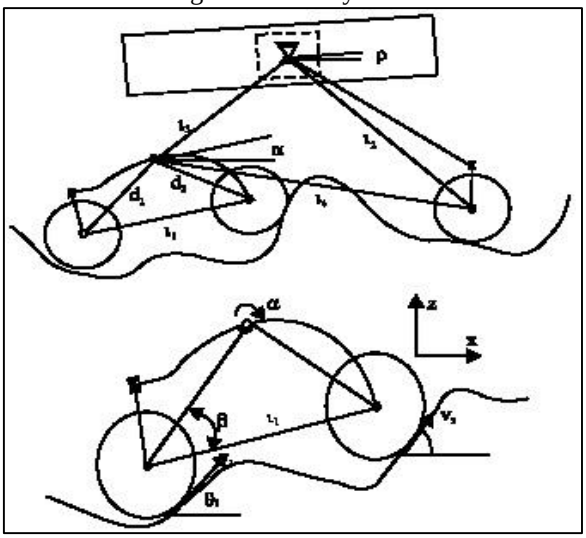

Fig. 2.1.1: Encounter area of rocker bogie suspension system

As accordance with the motion to maintain centre of gravity of entire vehicle, when one rocker moves up-word, the other goes down. The chassis plays vital role to maintain the average pitch angle of both rockers by allowing both rockers to move as per the situation. As per the acute design, one end of a rocker is fitted with a drive wheel and the other end is pivoted to a bogie which provides required motion and degree of freedom.

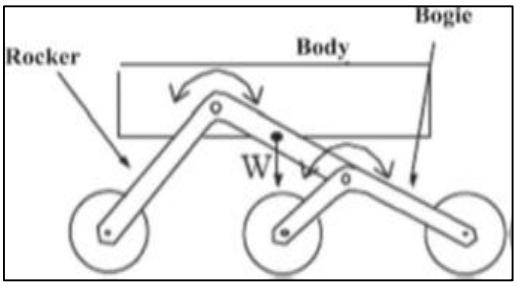

Fig. 2.1.2: Line diagram of Rocker-bogie suspension system.

B. Bogie

In the system, "bogie" refers to the conjoining links that have a drive wheel attached at each end. Bogies were commonly used to bare loading as tracks of army tanks as idlers distributing the load over the terrain. Bogies were also quite commonly used on the trailers of semi-trailer trucks as that very time the trucks will have to carry much heavier load.

C. DC Motor

A DC motor is any of a class of rotary electrical machines that converts direct current electrical energy into mechanical energy. The most common types rely on the forces produced by magnetic fields. Nearly all types of DC motors have some internal mechanism, either electromechanical or electronic, to periodically change the direction of current flow in part of the motor.DC motors were the first type widely used, since they could be powered from existing direct-current lighting power distribution systems. A DC motor's speed can be controlled over a wide range, using either a variable supply voltage or by changing the strength of current in its field windings. Small DC motors are used in tools, toys, and appliances. The universal motor can operate on direct current but is a lightweight motor used for portable power tools and appliances. Larger DC motors are used in propulsion of electric vehicles, elevator and hoists, or in drives for steel rolling mills. The advent of power electronics has made replacement of DC motors with AC motors possible in many applications.

Fig. 2.3: DC Motor

D. Control Unit

The small board does great job in controlling 2x DC motors through RF Remote Control. WE can easily make a robot out of this board that can be directed from remote control. Just add battery, motors and chassis. Good thing about the board is that it is possible to add external microcontroller to expand the functionality through serial UART pins provided on board.

Board can be operated in two modes, Auto mode (default on startup) and Manual Controller Mode. In Auto mode the DC motors are controlled totally from hand held RF Remote and it outputs the decoded remote data serially on its TXD pin for external controller to take further action if required. In manual controller mode the DC motors are not operated from RF Remote but the external controller sends it serial characters whenever motors are to be controlled.

1) Features

- Drives 2x DC Motors(Forward, Reverse, Left and Right)
- 3 Speed Control mode
- Can work from any battery from 9-15V
- Onboard 5V 1 Amp Regulator based on LM7805
- LEDs for Motor Direction and Power
- Can operate in Auto or Manual Control mode by external controller

E. Power Unit

- Brand Luminous
- Model Number 6V - 5Ah (Battery) Sealed Maintenance Free
- Type Offline/Standby
- Input Voltage 6 V
- Input Frequency 6V
- Output Power Wattage 86.4 W

III. WORKING

As per the research it is find that the rocker bogie system reduces the motion by half compared to other suspension systems because each of the bogie's six wheels has an independent mechanism for motion and in which the two front and two rear wheels have individual steering systems which allow the vehicle to turn in place as 0 degree turning ratio. Every wheel also has thick cleats which provides grip for climbing in soft sand and scrambling over rocks with ease. In order to overcome vertical obstacle faces, the front wheels are forced against the obstacle by the centre and rear wheels which generate maximum required torque. The rotation of the front wheel then lifts the front of the vehicle up and over the obstacle and obstacle overtaken. Those wheels which remain in the middle, is then pressed against the obstacle by the rear wheels and pulled against the obstacle by the front till the time it is lifted up and over. At last, the rear wheel is pulled over the obstacle by the front two wheels due to applying pull force. During each wheel's traversal of the obstacle, forward progress of the vehicle is slowed or completely halted which finally maintain vehicles centre of gravity. The above said methodology is being practically proved by implementing it on eight wheel drive ATV system in order to gain maximum advantage by rocker bogie system.

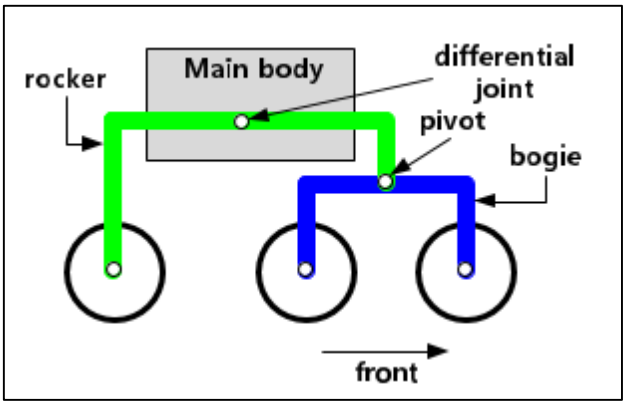

Fig. 3: Constructional dia. Of mechanism

IV. ADVANTAGES

1) Can climb over blocks twice the height wheel.
2) No need of special suspension system like spring.
3) Power available to all wheels hence easy to drive on irregular road surface.
4) Excellent stability and adaptibity.
5) Light in weight construction.
6) It can distribute load on each wheel.

V. EXPECTED OUTCOMES

In our project we have to climb the obstacles or ride on the abnormal surface with the help of such a rocker bogie mechanism. This mechanism serves our objective because of its nature of allowing flexibility in linkages when wheel climb or goes from the abnormal road surface. Hence we does not need extra suspension arrangement. Also series of mobility experiments in the agriculture land, rough roads, inclined, stairs and obstacles surfaces concluded that rocker bogie can achieve some distance traverses on field.

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